

Application No: 10/529,358  
Attorney's Docket No: NL 020908

### SPECIFICATION AMENDMENTS

Please replace paragraphs 0005, 0007, 0010, 0024, 0025, 0027, 0028, 0029, 0032, 0033 and 0039 with the following rewritten paragraphs:

[0005] Fig. 2 illustrates the basic structure of a conventional SDM 22. The SDM 22 includes an adder 12, a ~~loopfilter~~ loop filter 14, and a quantizer 16. SDMs may be implemented as analog or digital SDMs.

[0007] Another way of adjusting the SDM 22 is to change the coefficients of the SDM 22. Fig. 3 illustrates a conventional topology for a feedforward SDM 30. As illustrated, the feedforward SDM 30 is a fourth order SDM which includes four delay elements  $T_1$ - $T_4$ , four coefficients  $c_1$ - $c_4$ , adders 34 and 38 and a quantizer 36. A change to lower or higher SDM structures can be made by removing or adding delay elements  $T_n$  or coefficients  $c_n$ . It might be expected that reducing the last coefficients to zero, should give a stable lower order SDM. However, this is not easily accomplished because the resulting modulator may not always be stable. As a result, the stability requirement substantially restricts the freedom in choice of ~~loopfilters~~ loop filters of an SDM.

[0010] Advantageous embodiments are defined in the dependent ~~Claims~~ claims.

[0024] Fig. 4 illustrates an adaptive SDM 102 in an exemplary embodiment of the present invention. As illustrated, the adaptive SDM 102 includes an adder 12, a ~~loopfilter~~ loop filter 44, and a quantizer 16. The ~~loopfilter~~ loop filter 44 includes at least two filters  $H(z)$  and  $L(z)$ , where, for example,  $H(z)$  is a high order filter (giving low compression ratios) and  $L(z)$  is a low order filter, an adder 48 and an amplifier 46. The amplifier 46 can vary the weight of the filter  $H(z)$  with respect to the filter  $L(z)$ . These filters can be designed such, that any linear (parallel) combination of these filters will result in stable operation of the adaptive SDM 102, until the noise shaping of the SDM 102 becomes too aggressive, as people skilled in the art

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know. Still many degrees of freedom ~~exists~~ exist for the choice of filters. This in turn gives the possibility to balance the reduction in audio quality against the increase in compression ratio.

[0025] As an example, consider a third order ~~loopfilter~~ loop filter for  $L(z)$  (characterized by  $c_1 = 0.69$ ;  $c_2 = 0.183$ ;  $c_3 = 0.016$  in Fig. 4) and a fifth order for  $H(z)$  (characterized by  $c_1 = 0.00300$ ;  $c_2 = 0.00267$ ;  $c_3 = 0.00105$ ;  $c_4 = 0.000222$ ;  $c_5 = 0.0000189$ ; in Fig. 4).

[0027] It is noted that although one of the general concepts of the present invention has been applied to an SDM in the embodiment of Figs. 4-5, this concept could also be applied to other structures as would be known to one of ordinary skill in the art. For example, the general concept described in conjunction with Figs. 4-5 could also be applied to a noise shaper, as illustrated in Fig. 6. As illustrated, the noise shaper 200 includes a ~~loopfilter~~ loop filter with the same function as 44 of Fig. 4, quantizer 16, and two subtractors 48,50.

[0028] Low order SDM modulators have the undesirable characteristic of displaying (sometimes) audible tones, and harmonic distortion. It is conceivable that when the setting of the amplifier 46 is such that the resulting SDM 102 (or noise shaper 200) is foremost third order, it will inherit these characteristics. Replacing a single SDM (or noise shaper) by a cascade of two or more SDM's (or noise shapers) reduces this drawback. A filter/delay pair is placed between each adjacent pair of SDMs (or noise shapers). The combination of the cascaded SDMs (or noise shapers) and the filter/delay pair(s) ~~reduce~~ reduces amplitude errors in the output bitstream. A filter may also be placed in parallel with at least one SDM (or noise shapers). The parallel ~~filter(s)-reduces~~ filters reduce phase shift errors in the output bitstream.

[0029] An exemplary SDM device 100, which accomplishes this model in the digital domain, is ~~shew~~ shown in Fig. 7. The SDM device 100 includes a first SDM 102, a filter 104, a delay 106, and a second SDM 108.

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[0032] It is further noted that although the SDM device 100 of Fig. 7 reduces ~~for~~ amplitude errors, it is also possible to reduce phase-shift errors. These phase shift errors may be corrected as illustrated in the exemplary embodiment of Fig. 9.

[0033] In the exemplary embodiment of Fig. 9, the SDM device 200 includes a filter 202 to correct for a (frequency dependent) phase rotation of the input signal to filter 204. The filter 204 has a ~~lowpass~~ low-pass characteristic to reduce the high frequency noise. Finally, a delay 206 is used to compensate for all delays. The delays may be a non-integer fraction of the time step (in the digital domain), therefore, delay 206 might be more complicated than a sequence of flip-flops, but still within the skill of an ordinary artisan.

[0039] In summary, sigma-delta modulation is provided, wherein an input signal is ~~feeded~~ fed to at least two parallel filters, a first one of the filters preferably being a lower order filter and a second one of the filters preferably being a higher order filter, wherein output of the filters are is weighted and wherein the weighted output from the at least two filters is quantized, in order to enable a sigma-delta modulation with variable order.